A STUDY OF THE RELATION OF THE RELATIVE SIZE OF THE TWO HANDS TO SPEECH*

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SEVERAL years ago, the author noticed that his right hand was larger than his left hand. Afterwards he watched himself and found that the larger hand was performing acts which required gross movements and strength while the smaller hand was used in more dextrous activities. The observations indicated that there might be an existing relationship between the size of the two hands and laterality. A study[1] was conducted by the author at the University of Iowa to determine whether or not a difference in the size of the two hands was to be found generally. Of forty-six males studied, only 8.7 per cent were found to have both the right hand and the left hand equal in size.

Included in this study were thirty-four non-stutterers and thirty-three stutterers. A comparison of percentages of subjects having a larger right hand or left hand revealed no outstanding differences between the two groups. Since there is assumed to be a lack of dominant lead in the stuttering person, if we further assume that the difference in the size of the two hands is due to development through use, it might be expected that findings on non-stutterers and stutterers would not agree.

The Iowa study did not give a true indication of hand volume. The advisability of determining the amount of difference and comparing averages for non-stutterers and stutterers seemed apparent. Later, at the University of Michigan, an entirely new piece of apparatus was developed to measure the volume of the hand and a study was made of the hand volume of forty-four non-stuttering males and thirty-nine stuttering males.

* This is an abstract of a dissertation submitted in partial fulfillment of the requirements for the degree of doctor of science in the University of Michigan. The investigation was carried on under the direction of the following committee: Professors John H. Muyskens, Clarence L. Meader, Henry A. Sanders, Leon H. Strong, and Louis M. Eich. During its early stages, the investigation was conducted in the Graduate School of the University of Iowa under Dr. Wendell Johnson.

[1] Van Dusen, C. R., "A Study of the Relation of the Relative Size of the Two Hands to Speech," *Science*, 81, April 12, 1935, 363.

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Apparatus and Experimental Procedure

The development of a technique for determining the volume of the hand progressed in a series of studies: Series I, Series II, and Series III. In this paper, only the refined Series III apparatus and experimental procedure will be described.

Before making measurements it was necessary to decide upon a point of demarcation between the hand and arm which could be readily determined and marked. The carpal was chosen because of the ease and seeming accuracy with which it could be determined and marked in successive measurements. A special piece of apparatus was developed for making the markings. This consisted of a large flat board with a groove in which were inserted two small pieces of wood. In each of these was placed an upright piece of wood about the size of a pencil. The arm and hand were placed in the device with the wrist just above the groove. The pegs were moved inwardly and clamped, one peg falling at the extreme edge of the distal extremity of the ulna, the other at the extreme edge of the distal extremity of the radius. A straight line was drawn through the axis of the forearm over the dorsal side of the wrist. A ruler was laid across the arm with one edge resting against the pegs. A mark was made at the crossing of these two lines. While the markings were being made, the subjects were seated in the standard position described by Bayer and Gray.[2]

Volume measurements were made by immersing the hand and measuring the amount of liquid displaced. The apparatus used in the present study is shown in Figure 1. A level steel plate table was made movable by a hydraulic jack. Liquid in which the hand was immersed was contained in a three-litre beaker. Previous to each immersion the liquid level in the beaker had been brought to the lower edge of the outlet pipe by closing the outlet end, filling to a point above the level desired, and then allowing the surplus to flow into a container used only for that purpose. As the table was raised, displaced liquid flowed into a glass funnel. The funnel, attached to the beaker below the spigot, directed the overflowing liquid downward, through tubing which passed through a hole in the table, into the 500 c.c. graduated cylinder below. After the desired point on the wrist was reached, the hand was withdrawn, and the reading made.

The subject was seated in the rear of the apparatus, facing left

[2] Bayer, L. M., and Gray, H., "The Hand: Method of Measurement," *American Journal of Physical Anthropology*, 17, 1932–33, 379–415.

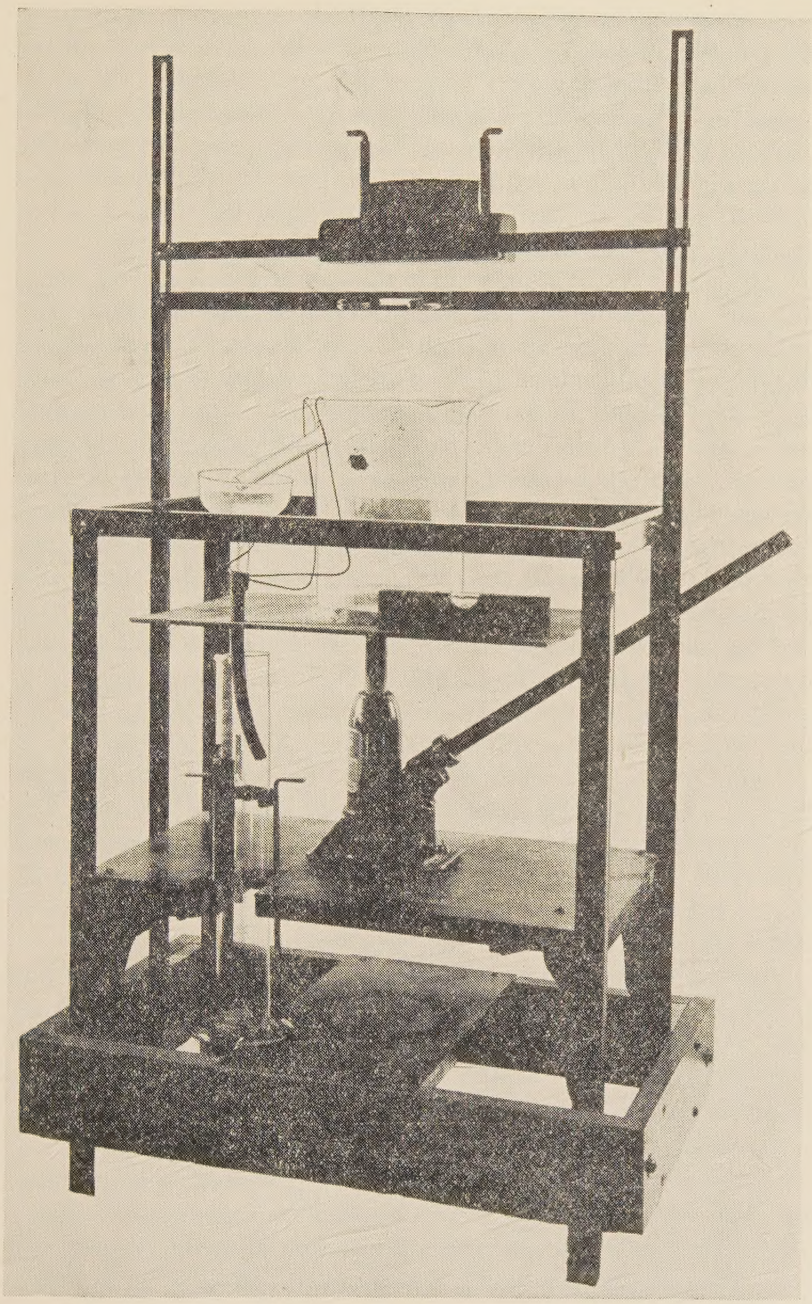

FIG. 1. Series III apparatus for determining the volume of the hand.

while the right hand was being measured, and facing right while the left hand was being measured. A wooden cushion with adjustable guides is shown above the table. The arm just above the elbow rested here. The arm was held steady in the adjustable clamps below. Slots in the upright side irons allowed for variations in the height of the wooden cushion and the adjustable clamps. Adjustments were made to suit the height and the arm length of individual subjects. A rubber sponge on the cushion lessened pressure on the arm.

Measurements were made as rapidly as possible. It was found advisable to have the beaker raised within an inch of the desired point so that as the hand was placed into the device a part of the displacement was completed. It was then necessary to raise the table but a short distance to complete the immersion. Measurements were made with the subjects seated in a well-lighted laboratory, the temperature of which was held at 68°F. The subject was required to remain quietly in a good sitting position ten minutes after marking, before the measurement was made. He was seated during this time in a straight-backed chair which had been placed in the correct position behind the apparatus. His hands were placed on his lap and he was asked not to move. He was told to remain relaxed throughout the procedure and that as the measurements were being made the experimenter would move the arm into place. He was told not to assist in the operation by use of his own energy.

After the displacement was completed, the arm was removed, the hand was dried, and the subject faced in the opposite direction. The subject sat quietly for ten minutes before the next measurement was taken. A new marking was made before each measurement. Water, held at body temperature, served as the displacement medium. The hand was left immersed for forty seconds.

Before making any measurements of the hand, the device was tested by making measurements on a solid. A kilogram weight with attachment was suspended from the mid-point of the adjustable clamp slot and measurements accomplished in a manner as similar as possible to that used with humans. Consistent volumes of 145 c.c. were obtained in the successive measurements.

To test further the reliability of the apparatus, repeated measurements were taken on forty right-handed non-stuttering males. A coefficient of $.9950 \pm 0.0016$ was obtained when first and second measurements taken on the right hand were correlated. A coefficient of $.9798 \pm 0.0064$ was obtained when first and second measurements

taken on the left hand were correlated. The mean of first measurements of right hands was 431.6 ± 8.2691; the mean of second measurements of right hands was 430.3 ±8.0790. The mean of first measurements of left hands was 414.3 ± 8.2002; the mean of second measurements of left hands was 417.0 ± 8.1408.

Characteristics of Cases

The volumes of the two hands of forty-four non-stuttering males and thirty-nine stuttering males were studied in the Series III investigation. Forty non-stutterers and thirty-seven stutterers were right-handed. Because of the small number of subjects in other classifications (left-handed and ambidextrous males in both groups, and all females) only the right-handed non-stuttering males and the right-handed stuttering males will be dealt with here.

Subjects in the non-stuttering group were students in the University of Michigan and Michigan State College. Subjects in the stuttering group were students at Michigan State College and at the Lewis Institute in Detroit. Ranges, means, and standard deviations for ages, heights, and weights of the two groups are presented in Table I.

All subjects were white and of American birth. Care was taken not to include subjects whose handedness had been changed nor whose bones in the arms or hands had been broken. Laterality tests were administered to all subjects.[3] Age was taken as the nearest birthday. Heights were obtained with the shoes removed. Weights were taken with the subjects uniformly clothed, 1.6 per cent of the obtained weight was subtracted to allow for clothing.[4]

Findings

Before comparing the two groups it was necessary to determine first whether or not mean differences for each group were significant. In studying the significance of differences between the averaged volume of the right hand and the averaged volume of the left hand

[3] A questionnaire study of hand-usage, tests of strength, speed, accuracy, and laterality lead were given. Findings from these tests have been studied in relation to hand volume and linear dimensions of the hand. This part of the investigation will be presented in a later publication. In the present study the subject's statement of hand-usage served as the indication of handedness.

[4] Subjects studied in Series I and Series II were quite similar to Series III cases in age, height, and weight.

of non-stutterers, the mean of the differences was obtained. This was found to be 14.8 c.c. A t-score[5] of 8.670 was obtained which indicates that the difference between the right and left hands of this group was highly significant. In studying the significance of the differences between the averaged volume measurements of the right and left hands of stutterers, a mean difference of 15.1 c.c. was obtained. The t-score, 8.737, obtained for this group, indicates that the difference between the right and left hands is highly significant.

The next step was to determine whether or not there was a significant difference between the two groups. A study was made of amounts of difference between the right hands and the left hands of non-stutterers as compared to the amounts of difference between the right hands and the left hands of stutterers. Fisher's formula[6] for comparing two means for separate groups was applied and a t-score of .1092 was obtained. This t-score indicates that the difference between the means of the differences for the two groups is not significant. Even though there is a significant difference between the mean volume of the right hand and the mean volume of the left hand in both groups, there is no significant difference when differences for non-stutterers are compared to stutterers.

Absolute and percentage frequencies of subjects having larger right hands, larger left hands, or both hands equal are presented in summary form in Table II. Percentages obtained for the right-handed group and for the left-handed group indicate either that the hand which is most used is larger or that the larger hand is most used, whichever the case may be. The per cent of subjects having both hands equal in volume is very small. In only the Series I study were there any subjects showing both hands to be equal in volume. It is probable that this is because the apparatus used was not as sensitive as was the Series II and Series III apparatus.

Absolute and percentage frequencies for all non-stutterers and stutterers are presented in Table III. A greater per cent of the right-handed male stutterers were found to have a larger right hand than left hand than were the non-stutterers. It seems that if there is a "lack of dominant lead in the stuttering person" handedness activity would be disintegrated more frequently in the stuttering group than in the non-stuttering group. It seems that right-handed stutterers would

[5] Fisher, R. A., *Statistical Methods for Research Workers*, London: Oliver and Boyd, 139, 1928, 104–107.

[6] *Ibid.*, 107.

have a larger right hand than left hand less frequently than would non-stutterers. Findings in this investigation do not bear out these assumptions.

Summary and Conclusions

1. Absolute and percentage frequencies indicate that the volume of the two hands is different generally.

2. This difference is statistically significant for a group of non-stutterers and for a group of stutterers.

3. When the mean of differences between the right hands and left hands of the non-stuttering group was compared with the mean of the differences between the right hands and left hands of the stuttering group no significant difference was obtained.

4. Absolute and percentage frequencies revealed a larger per cent of right-handed stuttering males having a larger right hand than left hand than there were right-handed non-stutterers having a larger right hand than left hand.

These findings would seem to indicate that, if the difference in the size of the two hands is due to use, the degree of assumed superior dominance of the left cerebral hemisphere over the right cerebral hemisphere is not sufficient to cause enough difference in laterality usage to result in any significant volume difference for non-stutterers and stutterers.

TABLE I

This Table Shows Ranges, Means, and Standard Deviations for Ages, Heights, and Weights of Right-handed Non-stuttering Males and Right-handed Stuttering Males Studied in Series III

	Group	Range	Mean	Standard Deviation
Age (years)	Non-stutterers	19 — 26	21.1±0.2469	1.5218±0.1746
	Stutterers	15 — 32	21.8±0.5833	3.5959±0.4125
Height (cm.)	Non-stutterers	155.6—189.2	176.3±1.6316	6.4424±0.7295
	Stutterers	153.3—193.0	175.8±1.2664	7.4919±0.8955
Weight (kg.)	Non-stutterers	54.9—114.3	72.0±1.9078	11.9145±1.3490
	Stutterers	53.1— 81.2	66.1±1.2389	7.3296±0.9861

TABLE II

THIS TABLE SHOWS THE TOTAL NUMBER OF RIGHT-HANDED SUBJECTS, THE TOTAL NUMBER OF LEFT-HANDED SUBJECTS, AND THE TOTAL NUMBER OF AMBIDEXTROUS SUBJECTS.

The per cent of subjects having a larger right hand, a larger left hand, or both hands equal is shown for each classification. This table is a summary of all adult subjects measured with the Series I, Series II, and Series III techniques.

Classification	Number of Subjects	R > L		R = L		R < L	
		No.	Per Cent	No.	Per Cent	No.	Per Cent
Right-handed Subjects	185	166	89.73	2	1.08	17	9.19
Left-handed Subjects	15	4	26.67	3	20.00	8	53.33
Ambidextrous Subjects	11	6	54.55	1	9.09	4	36.36
Total	211	176	83.41	6	2.84	29	13.74

TABLE III

THIS TABLE SHOWS ABSOLUTE AND PERCENTAGE FREQUENCIES OF SUBJECTS HAVING A LARGER RIGHT HAND VOLUME, A LARGER LEFT HAND VOLUME OR WITH BOTH HANDS EQUAL IN VOLUME.

This is a summary table and includes all subjects in Series I, Series II, and Series III.

Classification	Number of Subjects	R > L		R = L		R < L	
		No.	Per Cent	No.	Per Cent	No.	Per Cent
NON-STUTTERERS							
Right-handed males	79	70	88.61	1	1.27	8	10.13
Left-handed males	8	4	50.00	1	12.50	3	37.50
Ambidextrous males	5	4	80.00	0	.00	1	20.00
Right-handed females	44	40	90.91	0	.00	4	9.09
Left-handed females	3	0	.00	0	.00	3	100.00
Ambidextrous females	1	0	.00	0	.00	1	100.00
Total	140	118	84.29	2	1.43	20	14.29
STUTTERERS							
Right-handed males	54	49	90.74	1	1.85	4	7.41
Left-handed males	4	0	.00	2	50.00	2	50.00
Ambidextrous males	4	1	25.00	1	25.00	2	50.00
Right-handed females	8	7	87.50	0	.00	1	12.50
Left-handed females	0	0	.00	0	.00	0	.00
Ambidextrous females	1	1	100.00	0	.00	0	.00
Total	71	58	81.69	4	5.63	9	12.68
Grand Total	211	176	83.41	6	2.84	29	13.74

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